Staff Summary Sheet

	To	Action	Signature (Surname), Grade, Date		To	Action	Signature (Surname), Grade, Date
1	DFEM	Approve	O-6, 30 MAY	6			
2	DFER	Review	Krause, Col, 3 JUN 13	7			
3	DFEM	Action		8			
4				9			
5				10			

Grade and Surname of Action Officer	Symbol	Phone	Suspense Date
AD-24/Jensen	DFEM	333-7946	19 June 2013

Subject	SSS Date
Clearance of Material for Public Release Case Number: To be Assigned	30 May 2013

Summary   USAFA-DF-PA-374

1. Purpose: To provide security and policy review on the document at Tab 1 prior to release to the public.

2. Background:

- *Author(s)*: George York, Erlind Royer, Dan Harold and Dan Jensen, United States Air Force Academy

- *TITLE*: Assessment of a Multi-University Unmanned Systems Capstone Design Project

- *Abstract*:

In this paper we discuss the assessment methods for a senior capstone design project involving teams from three geographically separated universities, as well as the challenges the students faced and lessons learned. The project title was the Joint Cooperative Unmanned Systems Initiative (JCUSI). Each team was tasked with developing an unmanned autonomous system operating in a different medium (air, water, and ground) to cooperatively work together to complete a mission of protecting a harbor. JCUSI is unique in that the customer funding the project will most likely employ the students involved either as engineers implementing future unmanned systems or as operators of unmanned systems. Consequently, the sponsor was involved in defining the learning outcomes of the project, which were added to our normal pedagogical outcomes for this capstone engineering design course.

- *Release information*: Standard release of a USAFA technical report.

- *Previous clearance information*: N/A.

- *Recommended distribution statement*: Distribution A, Approved for public release, distribution unlimited.

3. Discussion:

To be published in *Proceedings of the Annual Conference- American Society of Engineering Education*

4. Recommendation: Sign coord block above indicating document is suitable for public release. Suitability is based solely on the document being unclassified, not jeopardizing DoD interests, and accurately portraying official policy.

Daniel D Jensen

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Department of Engineering Mechanics

1 Tab
Article, Assessment of a Multi-University Unmanned Systems Capstone Design Project

Assessment of a Multi-University Unmanned Systems Capstone Design Project

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Assessment of a Multi-University Unmanned Systems Capstone Design Project

Abstract

In this paper we discuss the assessment methods for a senior capstone design project involving teams from three geographically separated universities, as well as the challenges the students faced and lessons learned. The project title was the Joint Cooperative Unmanned Systems Initiative (JCUSI). Each team was tasked with developing an unmanned autonomous system operating in a different medium (air, water, and ground) to cooperatively work together to complete a mission of protecting a harbor. JCUSI is unique in that the customer funding the project will most likely employ the students involved either as engineers implementing future unmanned systems or as operators of unmanned systems. Consequently, the sponsor was involved in defining the learning outcomes of the project, which were added to our normal pedagogical outcomes for this capstone engineering design course.

1. Introduction

Multidisciplinary senior design capstone projects have been popular at many institutions for several years. Multidisciplinary projects are encouraged by the Accreditation Board for Engineering and Technology's requirements for a "realistic" major design experience,[1] with the recognition that projects in industry typically require multi-disciplinary teams. Another recent capstone trend reflecting life in industry is projects with geographically separated teams. These teams can range from multi-university teams in the same country[2] to international multi-university teams.[3,4] In addition to the traditional challenges of multidisciplinary teams, these teams are also faced with the challenges of being geographically separated, often with a different language or culture. Challenges include scheduling difficulties due to different time zones and school vacation schedules; coordination and communication challenges, not only due to not being co-located, but also due to different languages; and the impact of cultural differences between institutions, leading to different design and process approaches.[3,4] The students find that defining and documenting interfaces becomes even more important when geographically separated.[3]

In this paper we will look at an example of a project with teams from three geographically separated colleges: The U.S. Air Force Academy in Colorado Springs, Colorado, the U.S. Military Academy in West Point, New York, and the U.S. Naval Academy in Annapolis, Maryland. Each team was tasked with developing an unmanned autonomous system operating in a different medium (air, water, and ground) to cooperatively work together to complete a mission of protecting a harbor. This project is unique in that the customer funding the project will most likely employ the students involved either as engineers implementing future unmanned systems or as operators of unmanned systems. The sponsor was involved in defining the learning outcomes of the project, which were added to our normal pedagogical outcomes for this capstone engineering design course. These additional outcomes added assessment methods to our traditional course assessment. Before discussing the assessment methods, to help motivate the problem we will first discuss the scenario the three unmanned systems were challenged to solve,

the engineering challenges, and the technical results. We then discuss the desired outcomes, the assessment methods, and the assessment results.

2. Scenario

JCUSI is an undergraduate research project composed of teams from three universities to explore a cooperative control scenario involving multiple unmanned aerial vehicles (UAVs), unmanned surface vehicles (USVs), and unmanned ground vehicles (UGVs), as illustrated in Figure 1. Each team designed the UxVs their respective institution specialized in. In addition, one team designed the combined command center (CCC). These unmanned systems (UxVs) had to cooperatively and autonomously protect a harbor from intruding boats. The scenario begins with two UAVs searching the harbor entrance attempting to identify and track any incoming boats. To simplify the task, the intruding boat has a unique signature (bright orange color). Upon detecting the intruding boat, the UAV notifies its ground station, which in turn sends the detected target coordinates to the combined command center, which tasks a USV to intercept the intruding boats. The other UAV continues to search for other possible intruding boats, while the first UAV continually tracks the detected intruding boat and sends the location information to the USV via the UAV ground station and the combined command station. When the USV intercepts the intruding boat, it notifies the combined command center, which informs the UAVs, and then escorts the boat to the shore. At this point, the UAVs must detect and track another target, a human departing the boat with a unique signature (bright orange color, but smaller size). The UAVs loiter above the boat waiting to detect and track the human target leaving the boat. When the UAVs detect the human target, they notify their ground station that sends a message to the combined command center, which then tasks the UGVs to intercept the human. The scenario ends when the UGVs intercept the intruder and notify the combined command center.

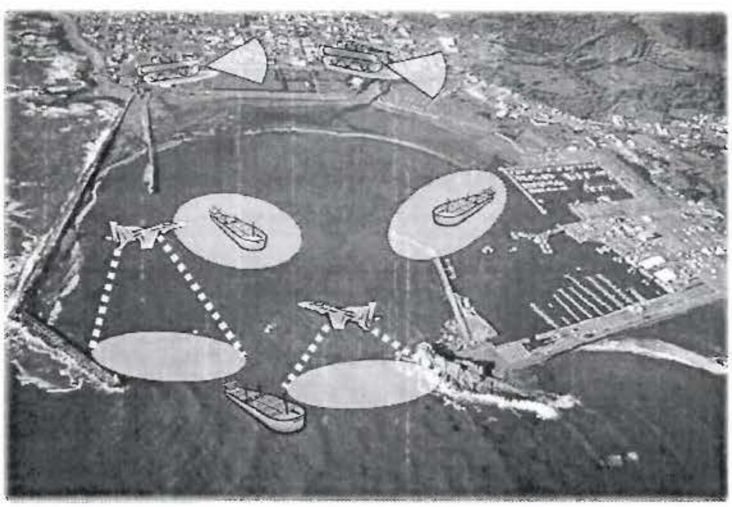

Figure 1. Harbor Protection Scenario. The tanks represent the UGVs, the green boats represent the USVs, the airplanes represent the UAVs, and the orange boat represents the intruder.

3. Engineering Challenges / Technical Results

The students had several engineering challenges. First, they had to design the top-level cooperative control architecture between three sets of unmanned systems as well as the communication infrastructure and protocols to support the architecture. The requirement was for the system to work fully autonomously; however, human intervention was allowed for confirmation of targets and overriding actions taken autonomously by the UxVs. Secondly, the processing and fusion of the heterogeneous sensor data from the three different platforms to track the targets while propagating the proper error ellipse proved to be very difficult. Thirdly, the communication architecture had to support the bandwidth of multiple video streams at distances up to a mile range with limited power radios. Finally, the architecture had to ensure all the ground stations, UAVs, USVs, and UGVs maintained "situational awareness" for their respective UxVs in a timely manner for control and safety while providing an overall situational awareness in the combined command center, which is responsible for the overall mission. The combined command center is shown in Figure 2.

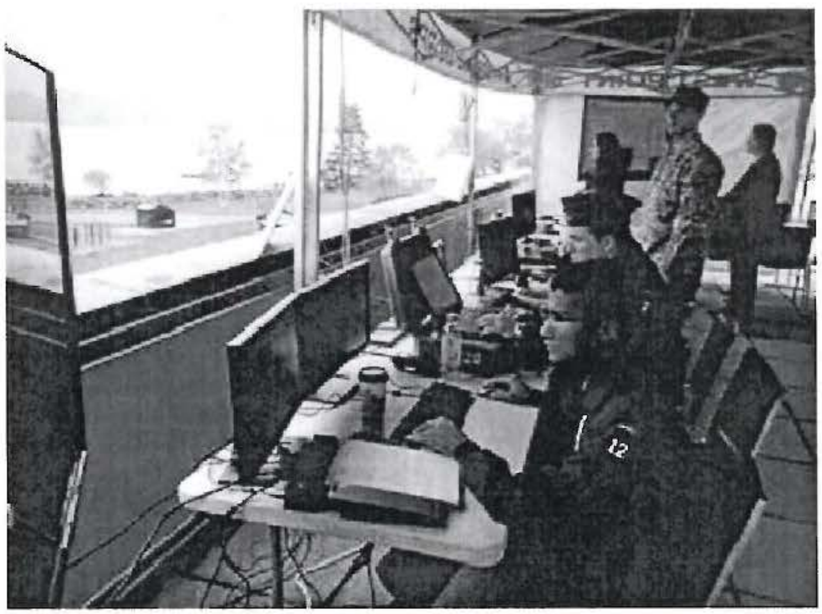

Figure 2. The combined command center (CCC), showing the ground control stations for the UAVs, UGVs, and USVs.

Each team had to tackle the low-level challenges unique for their platform. For example, the UAV team had to design or integrate the following subsystems: (1) an onboard computer system; (2) an onboard sensor system; (3) an autopilot system; (4) a ground control station, Figure 3; (5) a communication system between the two UAVs and the UAV ground station, which communicates with the combined command center; (6) image recognition software to detect and track moving boat and human targets (7) a backup manual radio control flight control system; and (8) onboard power for propulsion and the payload.

Figure 3. Example of the Graphical User Interface for the UAV Ground Control System. The left images are live images from the two UAVs and the center picture is the situational awareness image, with an icon representing the location of one UAV, and the green icon representing the location of one of the UGVs.

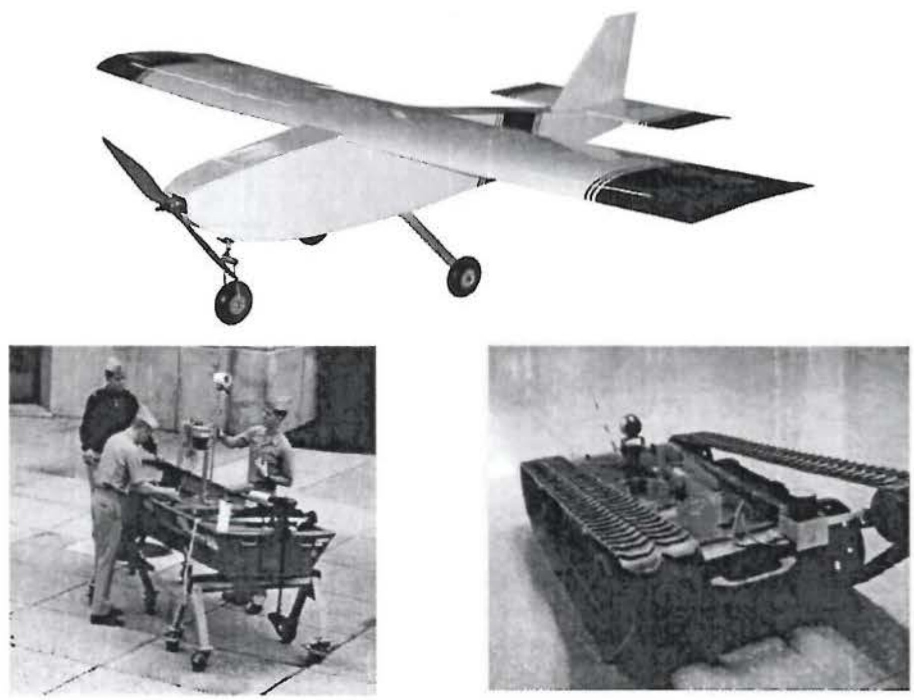

Figure 4. The UAV, USV, and UGV used in the project.

Figure 4 illustrates the three unmanned vehicles. In the final demonstration, each team was able to get their UxVs to work, but did not meet all the technical requirements. The autonomous tasks achieved are listed in Table 1. The UAV was able to detect, track, and relay tracking information of the target boat to the UAV ground station. The UAV autonomously detected the candidate target and a man-in-the-loop made the final decision to confirm the target at the UAV ground station. The USV was capable of autonomous navigation, but due to a mechanical failure was unable to intercept and escort the intruder boat autonomously. The USV's sensors were able to identify the target. The smaller size and glare of the human's signature prevented auto-detection by the UAVs, so a man-in-the-loop at the UAV ground station had to provide the human target location to the UGVs. The UGVs then successfully autonomously intercepted the ground target. The biggest technical issue was a failure to complete the final integration of the overall command center (CCC) with each team's ground control station, requiring a man-in-the-loop to rely target and status information during the demonstration. The students learned the lesson that they cannot just focus on getting their UxV system working, but have to worry about the details of interfacing with the other systems and not taking the interfaces for granted. Next year's JCUSI project hopes to successfully apply this lesson learned.

	Manual	Autonomous
UAV	Take Off and Landing	Plan Waypoints based on given Search Area
	Designate Search Area	Fly & Navigate to Waypoints
	Confirm Target proposed by UAV	Detect and propose Candidate Boat Targets
	*Detect and Track Human Targets	Track Confirmed Boat Target
		Communicate Target / Status to UAV/CCC ground stations
USV	* Intercept Target	Navigate to Estimated Target Location
	*Communicate with CCC/UxV stations	Detect/Identify Target
UGV		Navigate to Estimated Target Location
		Detect and Intercept Target
		Communicate with CCC/UGV stations

Table 1. Autonomous versus Manual control actually achieved. * indicates tasks intended to be autonomous, but not achieved.

4. Outcomes

The agreed desired outcomes of the JCUSI project were to develop young engineers who:

(1) Understand the current capabilities and limitations of unmanned system technology
(2) Can identify operational opportunities for unmanned systems

(3) Are able to develop and articulate unmanned system requirements
(4) Are able to function as part of a multi-institute, geographically dispersed team.

While outcomes 1 and 2 are unmanned systems focused, the challenges presented by outcome 3 (requirements) and outcome 4 (geographically separated teams) may be of interest to many system engineering projects.

In addition to these outcomes, we also assessed our regular capstone design course outcomes, which assess the students' performance following a defined rubric after each major project milestone. Our project milestones are the system requirements review (SRR), the preliminary design review (PDR), the critical design review (CDR), two system status reviews (SSR), the system verification review (SVR), and the final demonstration.

5. Assessment Methods

Three formal assessment activities were defined before the project started:

(1) A 38-question survey taken by the students at the beginning and the end of their participation in the project to measure their perceptions of their knowledge, skills, and attitudes as they pertain to the four project learning outcomes.
(2) The normal course assessment tools used in our two-semester capstone engineering design course (grades from the above program reviews)
(3) The project mentors' qualitative evaluation of the team's achievements.

In addition, other assessment opportunities became available during the course.

(1) The students had an opportunity to visit a UAS operational site mid-way through the project, so we conducted a survey to access the impact of meeting the real customers in the operational environment as they related to the four project learning outcomes.
(2) The students from the three universities had an opportunity to meet in person mid-way through the project, and we conducted a survey to access the impact of this meeting on the four project learning outcomes.
(3) Reflective papers by the students of their experience with the course.

6. Assessment Results

a. Survey Results

Figure 5 presents the results for the 38-question surveys that directly measured the students' perceptions of their attainment of the desired project outcomes. Appendix A contains the survey questions. All of students on the team took both surveys and each answered all the questions. The chart shows the average response to each question at the beginning of the project and at the end. The questions are grouped by project objective with the first objective's 14 questions the first group on the left.

Of note in Figure 5 is that the students' average responses for each objective are markedly higher at the end of the project. The largest improvement was for Objective 1-'understand unmanned

systems capabilities and limitations' where their average response changed from slightly above "Disagree" to 1/2 way between "Agree" and "Strongly Agree." Figure 5 demonstrates that the students felt the project significantly helped them toward the project objective.

For Objective 4, the students appear to believe this project helped them with experience working on geographically separated teams with different cultures. The survey showed improvement for all questions, such as:

> "I can manage deadlines across times zones"
>
> "I can coordinate meetings and teleconferences across time zones and can lead and contribute to these meetings using language familiar to all teams/communities"
>
> "I can better understand the culture and expectations of the other teams/communities"
>
> "I am able to develop visual aids to communicate concepts to those not physically present"
>
> "I can clarify expectations to the geographically separated teams"
>
> "I have a better appreciation for the problems, constraints, and solutions that the different teams encounter."

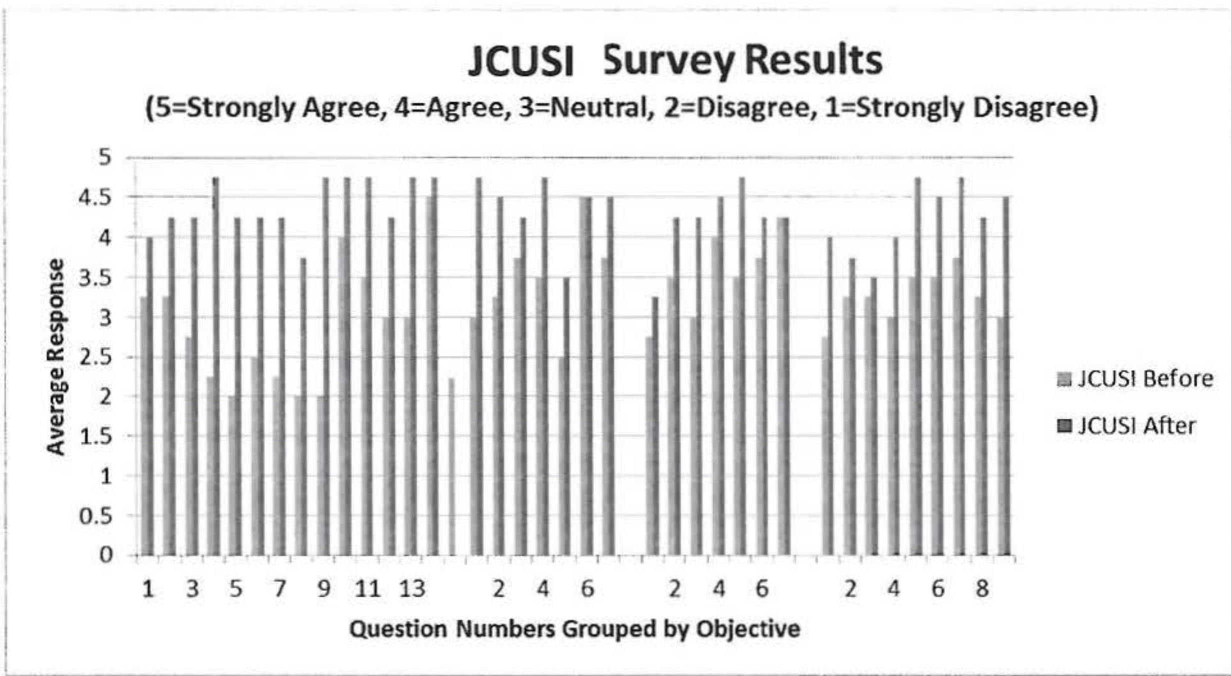

Figure 5. Students' Perceptions of their Attainment of the JCUSI Project Objectives

The students working on the JCUSI project made an orientation trip to an unmanned systems operational site early in the course to view training operations and interact with pilots and operators flying operational Unmanned Aircraft Systems (UAS) missions. The impact of the trip was assessed with a survey given before and after the trip. Figure 6 displays the results and

Appendix B lists the questions. Questions 13-16 were added for the survey after the students returned to measure specific desired learning outcomes. Of interest in these results is that the students had high expectations for the trip (Question 2) and the trip met their expectations. The students achieved the learning outcomes as the average responses ranged from "Strongly Agree" to "Somewhat Agree" after the trip except for Question 6. The students seemed more interested in designing UAS than being the user/operator of a UAS.

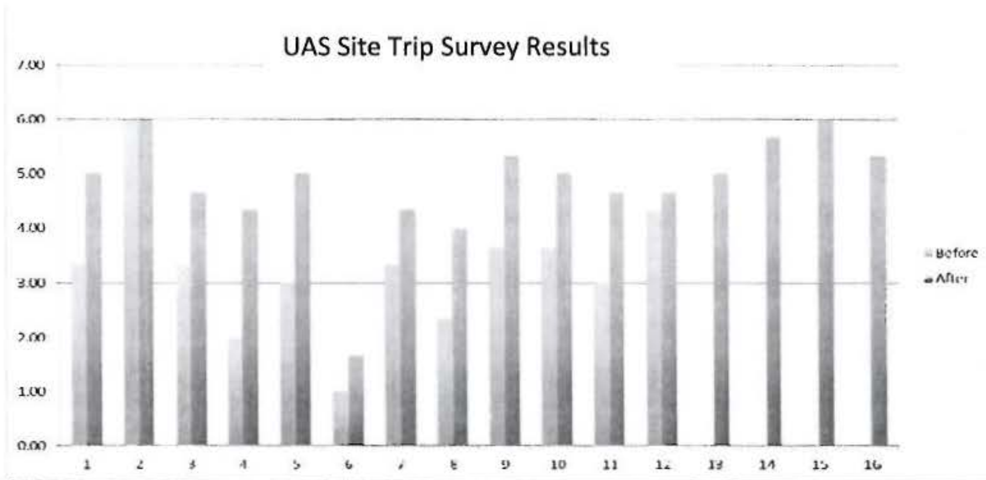

Figure 6. Results of the Unmanned Systems Operational Site Trip Survey

The final survey results in Figure 7 show the significant increase in knowledge, skills, and positive attitudes after the students' trip to meet with their counterparts at the other universities midway through the project. Although students' anecdotal comments tended to decry the lack of coordination they were able to obtain at the meeting on specific technical details, it is very clear that the cumulative effects of the unmanned systems operational site trip and the trip to meet the other university teams have had a very significant positive impact.

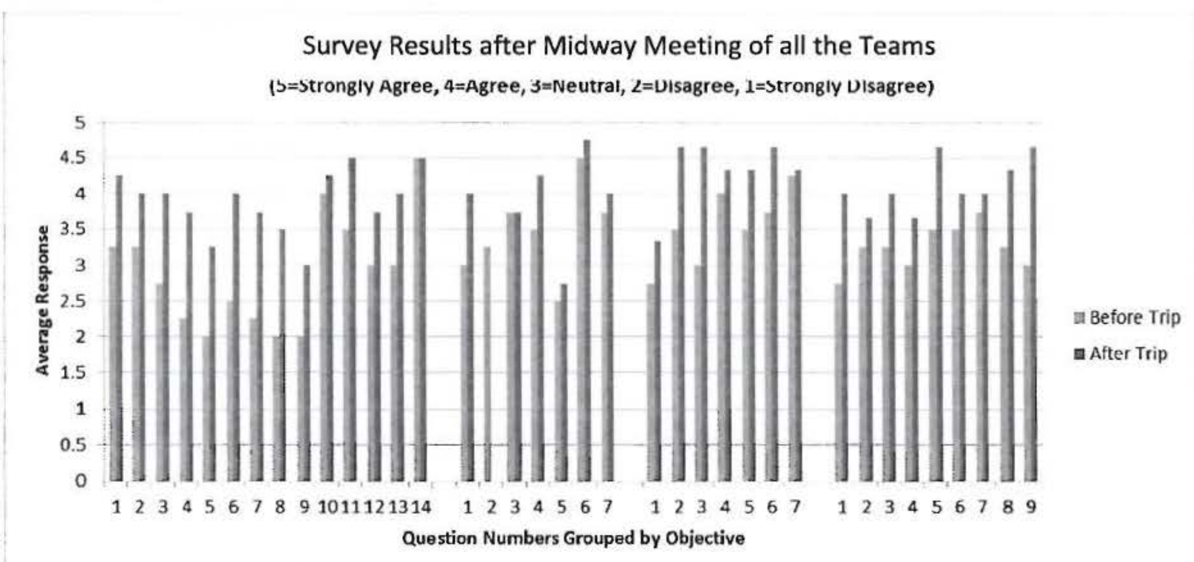

Figure 7. Survey Results after the Meeting of all Teams Midway through the Course

b. Assessment using the Capstone Course Tools

We also assessed the team using our normal course assessments, which primarily follow our project milestones. The project milestones are the system requirements review (SRR), the preliminary design review (PDR), the critical design review (CDR), two system status reviews (SSR), the system verification review (SVR), and the final demonstration. The most applicable for the assessment of our customer objective #3 (requirements) is the Systems Requirements Review (SRR). We will not present our students "grades" in this paper, but have included the detailed "expectations/rubrics" we used to assess the students' performance in the SRR in *Attachment 3* as an example. Contact the author if you are interested in the detailed rubrics we use for the other reviews.

c. Project Mentor's Assessment

The six mentors involved with this project met after the end of the semester. The following are the mentors' conclusions and lessons learned grouped by the JCUSI objectives:

1. Understand the current capabilities and limitations of unmanned system technology
    - The trip to a UAS operational site was a great motivator and learning experience. Students greatly increased their understanding of the problems inherent in autonomous operation and automatic target detection.
    - The students gained an appreciation that it takes sustained effort and persistence to successfully coordinate operations and control of three different unmanned systems to achieve a goal.
2. Can identify operational opportunities for unmanned systems
    - One team's passion for unmanned systems as essential, life-saving systems made a big impression on the other teams.
    - Learned enough about capabilities/limitations to make better decisions on employing unmanned systems.
3. Are able to develop and articulate unmanned system requirements
    - The team struggled to find a systematic way to flush out all the requirements for this complex scenario and system. More guidance from mentors may have helped.
    - The students perhaps learned more from their failure to identify verifiable requirements than from doing it properly the first time.
    - The process of testing each requirement fell apart at the end when the schedule got tight.
4. Are able to function as part of a multi-institute, geographically dispersed team
    - Enthusiasm for working with the other universities significantly increased after trip to meet the other teams.
    - The students understand much better the difficulty involved in coordinating and conducting meetings working across time zones with different academic and vacation schedules.
    - Greatly appreciate the difficulty in achieving true interoperability and the importance of agreeing to and maintaining communication interfaces.

- Logistically and operationally were much better prepared than the previous year. The host university preparations were excellent with dedicated work areas for each team, machine shop support, and a prepared landing strip.
- Lessons Learned: Communications interfaces should be defined early, not be changed without full coordination, and be tested remotely prior to demonstration
- Lessons Learned: Teams should develop a coordinated, detailed Joint Test Plan for the prep day and the demonstration
- Lessons Learned: Should hold more teleconference or video conference coordination meetings; an earlier face-to-face meeting in the fall would help set up these meetings.

7. Student Reflections and Lessons Learned

The students each wrote an essay reflecting on the insights and benefits they gained and lessons learned from the project. Many of the comments involved challenges working with geographically dispersed teams and the different cultures of the teams. Every team was eager to work with the others, but they all had different biases, perceptions, and stereotypes of the other teams. This tended to go away after they became better acquainted.

The different cultures created challenges even with simple tasks. Each school had developed their own terminology for their unmanned systems (air, water, and ground systems have different terminology for the same functions), which was an obstacle in communicating when designing the top-level architecture. For example, the unmanned aerial system team liked to use the work "search" for the same task the unmanned ground system team used for "recon." This communication problem wasted a lot of time in the early teleconferences. There were issues agreeing on data formats. For example, one team wanted DMS (degrees-minutes-seconds) for coordinates, while another insisted on MGRS (Military Grid Reference System). They also found each team had developed their own approach to solving the problem and it is hard to get people to change course after they have invested time and effort in their own approach.

Being geographically separated brought up several challenges. Each university and each student had different schedules, time zones, and school holidays making scheduling teleconferences with all the key players difficult. Doing the integration testing of the systems remotely was difficult, so the teams put off much of the integration testing until they would be co-located the day before the final demo. This did not work well, as all the teams found they had problems with their own unmanned systems to fix, so much of the joint integration testing/debugging was not done until the live demo.

There were also many comments about the challenges facing unmanned systems in the operating environment, their limitations, and the amount of autonomy that can or should be given to the systems. They learned that there are many trade-offs between being fully autonomous or fully human controlled, and that the best systems need a method whereby the user can control the level of autonomy, taking control of the system when needed. They also learned about Murphy's Law, which applies especially well to unmanned systems. They gained an appreciation for not being overly optimistic and more cautious in system design and scheduling.

Finally, the last group of comments surprised us in that our students gained more appreciation for the importance management and system engineering has in these complex projects. Our students were from the disciplinary majors of electrical engineering and computer engineering, and came into the course with little respect for system engineering, thinking the "real" engineering is at the disciplinary level. One comment was "I learned a lot more about Systems Engineering Management and the need to think about every possible detail." One of the biggest benefits they believe they have gained is having developed much stronger planning skills for complex systems.

8. Conclusions

The students were able to experience the management and engineering challenges of a large engineering project while attempting to get three geographically separated teams to work together. Coordination difficulties were exacerbated by two different time zones, different work schedules, different terminology, and varying philosophies on how to solve the problem. Additionally, each team faced their own internal challenges with their individual multi-disciplinary teams. In the end, the final demo was mostly a success, but the teams learned a valuable lesson about the importance of defining interfaces as their systems all had trouble communicating with the combined command center.

We found the customer-generated objectives useful for assessing the outcomes for this capstone team. We initially only had funds for the teams to travel to the final demonstration, but fortunately the sponsor found funds for two other trips mid-way during the design phase, which were very beneficial. We highly recommended for other similar projects to (1) visit a site that uses the intended systems to see the challenges and limitations faced by the operators and maintainers of the systems, and (2) meet in-person with the other teams as early as possible to help establish rapport and facilitate later remote communication among the teams.

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3. J.L. Ellingson, C.S. Greene, S.E. Morgan, and M.A R. Silvestre, "An International Multiyear Multidisciplinary Capstone Design Project," *Proceedings of the 2012 American Society for Engineering Education Annual Conference & Exposition.*
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6. *System Engineering Fundamentals,* Defense Acquisition University, Fort Belvoir, VA, January 2001.

Appendix A. JCUSI Student Survey

Objective 1: Understand the Capabilities and Limitations of Unmanned Systems
1. I can describe how common sensors in unmanned systems are typically used and the advantages and disadvantages they offer.
2. From working on this project, I have a clearer understanding of the capabilities and limitations of air, ground, and marine vehicles.
3. I understand the typical signal processing that an unmanned system must perform.
4. I know how to integrate control system design concepts into an unmanned system design.
5. I can articulate the levels of autonomy and required key aspects of the autonomy algorithms
6. I can perform platform and sensor selection using objective criteria.
7. I know how to develop the requirements necessary to interface different platforms and subsystems.
8. I can plan for the necessary logistical requirements involved in testing and operating an autonomous system.
9. I have the general skills necessary to debug and troubleshoot an unmanned system in the field.
10 I have an appreciation of the challenges faced by field operators of unmanned systems.
11. I understand the level of robustness and redundancy required of fielded unmanned systems.
12. I understand the capability gap between prototypes and systems that are ready to be deployed and fielded.
13. I have a better appreciation for the challenges in developing robust and fully autonomous solutions.
14. I understand why unmanned systems are important to DoD.
Objective 2: Identify Operational Opportunities for Unmanned System Solutions
1. I know many of the capabilities and limitations of unmanned systems and can determine the best role for them in the operational force.
2. I can list many of the challenges unmanned systems face in the operational force.
3. I can identify tasks that can be potentially automated or replaced by an unmanned system.
4. I can identify the level of autonomy required for a particular task and can determine the potential role of a human operator.
5. I can estimate the time required to develop a system and the probability of success of an approach.
6. I believe that autonomous systems have the potential to enhance military operations
7. I feel that defense industrial partners and government laboratories are equal partners in developing solutions for unmanned systems.
Objective 3: Develop and Articulate Unmanned System Requirements and Specifications
1. I have knowledge about the current state-of-the-art commercially available unmanned systems.
2. I understand how operational needs can translate to the technical requirements of a system.
3. I can use a formal engineering design process to generate the specifications and performance measures from high level requirements.
4. I can separate the desired functionality from a specific design solution.
5. I understand the importance of possessing both technical and operational skills to generate a requirement.
6. I appreciate the need for testable or demonstrable requirements.
7. I understand that vendors and non-military personnel often use a different terminology and have a different culture than the military.
Objective 4: Function as Part of a Multi-institute, Geographically Dispersed Team.
1. I better understand the terminology used by other teams/communities.
2. I better understand the culture and expectations of the other teams/communities.
3. I can coordinate meetings and teleconferences across time zones and can lead and contribute to these meetings using language familiar to all teams/communities.
4. I can produce documentation readable by the other teams/communities.

5. I can clarify expectations to the other teams/communities.
6. I can manage deadlines across time zones.
7. I am able to develop visual aids to communicate concepts to those not physically present
8. I feel a more team-oriented cooperative spirit across the teams.
9. I have a better appreciation for the problems, constraints and solutions that the different teams encounter.

Appendix B. JCUSI Student Survey for Unmanned System's Operational Site Visit

1	I would rate my understanding of UAS operations as
2	This trip will aid my understanding of UAS operations better than if we spent this lesson in the classroom
3	I would rate my understanding of the system engineering requirements for designing, testing, and maintaining UAS systems as
4	I would rate my understanding of the maintenance and logistics requirements for UAS systems as
5	I would rate my understanding of the global nature of the operational US UAS systems as:
6	I would rate my desire to become a UAS operator as
7	I would rate my desire to become an engineer working on UAS systems as
8	I would rate my understanding of the coordination required between UAS operators and soldiers on the ground as
9	I would rate my understanding of the need for joint (Army, Navy, and Air Force) operations using unmanned systems as
10	I would rate my understanding of the roll of unmanned systems in military operations
11	I would rate my understanding of possible future UAS military operations as
12	I would rate my preparation to become an engineer as
13	I have greater knowledge about the capabilities and limitations of current UAS systems
14	I have a better understanding of how operational needs can be met by the technical capabilities in current UAS
15	I have a better understanding of how autonomous systems can enhance military operations
16	I have a better appreciation of the challenges faced by field operators of unmanned systems

NOTES: The 'before the trip' survey questions were preceded by "Before going on this trip," and the 'after the trip' questions by "After going on this trip,". Questions 13-16 were added for the 'after' survey to measure specific desired learning outcomes.

Appendix C–System Requirements Review - Expectations and Rubrics

1. **Purpose:** The System Requirements Review (SRR) is a formal briefing by your project team to convince your mentor, senior reviewing officer, faculty representative, and, as appropriate, your customer, that you fully understand the problem you are trying to solve. Recall that the purpose of the SRR is to ensure that you, as the design team, your mentor, and your customer, have the same understanding of the requirements. As noted in DAU's *System Engineering Fundamentals*, (p. 104) "The SRR is intended to confirm that the user's requirements have been translated into system specific technical requirements ... and that risks are well understood and mitigation plans are in place." There should be **NO** discussion of design solutions in this review.

2. **SRR Deliverables**:
- Requirements: 30%
    - Requirements Traceability Matrix (MS Excel) Detailed overview in an Objective Tree
- Functional Description: 15%
    - Functional Flow Block Diagram (FFBD) of the top level system functions (MS Visio) Can be presented in the slides
    - OV-1
    - User Interface (UI) Mockup
- Project Plan: 20%
    - Schedule with progress to date, details to PDR and an overview of the entire year. (MS Project, with critical path analysis in slides)
    - Risk Analysis (MS PowerPoint Slides)
    - Configuration Management (MS PowerPoint Slides)
    - Contemporary Issues (MS PowerPoint Slides)
- Presentation: 35% (MS PowerPoint)
    - Communicate:
        - Summary of your project requirements
        - Current status, along with any issues and your plan to resolve them
        - Your detailed plans for the next phase of the project
    - Present a dry run of your briefing to your mentor one lesson prior to the SRR
    - The team's presentation should run for **55 minutes or less** to allow for questions afterward

3. The attached rubrics show the grading weights for each portion of each deliverable. **NOTE**: If any of the deliverables submitted for this design review earn Unsatisfactory (<67%) marks, they must be resubmitted within one lesson period of receiving feedback. If the presentation receives an Unsatisfactory mark, it must be redone.

4. Each individual will also receive a grade for their individual performance and contributions to the team. The individual grade will be combined with the team grades as described in the syllabus. Each team member will be evaluated based on:
- The appropriateness of work accomplished based on their individual skill set
- The amount of work accomplished
- Interpersonal skills

Bring your lab notebooks to the design review so your faculty team can review them. Make it clear in the presentation what each member has done.

5. Peer Evaluations. Prior to the start of the SRR each student must complete a Peer Evaluation using the survey posted on the course homepage.

Requirements: 30%

Requirements Traceability Matrix.

Area (weight)	A Work	B Work	C Work	Unsatisfactory
Requirements Traceability Matrix and Objective Tree (100%)	• Requirements achievable, unambiguous, consistent & verifiable • Cover input/output, physical constraints, performance and environment • Threshold & objective specified if applicable • KPPs identified • Ambiguities identified with get-well plans; • Functional allocation complete and logical	• Several minor requirements issues	• Significant problems with requirements, problem areas overlooked, allocation problems • Some ambiguous requirements lack get-well plans; • No objective requirements • Some acceptance tests not clear or specified • No KPPs	• Requirements poorly written; • Many ambiguities, unclear acceptance tests or allocation problems • **NOT PRE-COORDINATED WITH CUSTOMER**

Functional Description: 15%

Functional Flow Block Diagram

Area (weight)	A Work	B Work	C Work	Unsatisfactory
FFBD (60%)	• Thoroughly describes the top level system functions • Logical breakdown and arrangement of functions; • Correct syntax for FFBD	• Several minor oversights, logic errors or diagramming errors	• Some functions omitted or some logic errors describing behavior • Significant FFBD syntax errors which obscure the function being described	• Does not describe system behavior; • Does not follow FFBD syntax to the extent that the function is unclear
OV-1 and UI Mockup (40%)	• Clearly demonstrates proposed system concept • Clearly identifies boundaries and relationships to external systems • UI shows inputs and outputs, is logical and complete • Professional/easy to read	• Several minor ambiguities, oversights or other issues	• Simple presentation • Significant portions of graphics not clear • Significant boundaries or external relationships not covered • Significant user interface issues	• Unclear operational concept; External systems and boundaries not addressed • User interface provides no insight to operator • Sloppy presentation • **NOT PRE-COORDINATED WITH CUSTOMER**

Project Plan: 20%

Includes: Schedule (MS Project) and MS PowerPoint Slides on Risk Management, Configuration Management, and Other Considerations (Environ./political/social, Health/Safety, Economic, Manufacturability/Sustainability, Ethics)

Area (weight)	A Work	B Work	C Work	Unsatisfactory
Schedule: (70%)	• Detailed and logically linked set of tasks that thoroughly cover the activities required to achieve PDR • Overview of entire project • Includes risk management &	• Plan is complete with several minor issues with task descriptions, linkage or resource allocation	• Significant tasks missing • Some tasks vague or not linked • Workload allocated to resources but has significant balance problems	• Major PDR tasks missing • Schedule unusable because not linked, resourced, or because of serious logic problems

	documentation tasks • Resources logically allocated for each task			
Risk Management (10%)	• Risks are assessed against meeting a documented requirement and are logical; • Solid analysis support for probabilities and consequences; • Logical and achievable management plans and strategies	• Few general risks; • Few probabilities and consequences lack solid analysis support; • Few management plans vague	• Some generic risks; • Some analysis support for probability and consequence analysis is supported, some is vague; some is missing • Some management plans are vague	• Mostly generic risks; • Little or no support for probability and consequence analysis; • Some key risks are ignored • Management plans either do not exist or are vague
Config Mgt (10%)	• Plans workable, cover all products, evidence of use	• A few minor oversights	• Some anticipated design products not discussed	• Only cursory treatment of configuration control
Contemporary Issues (10%)	• Issues thoughtfully considered; • Concerns and actions required documented and in the project schedule	• Few minor issues	• Minimal thought about issues. Significant oversights • Management plans contain little detail	• Only cursory attention, with vague if any management plans

SRR Presentation: 35%

MS PowerPoint Slides and presentation that:

- Clearly communicate the purpose and goal of the project as you have agreed with your mentor
- Clearly describe the current status of the project including get-well plans for any issues
- Clearly describe your plan to achieve a successful PDR

Area	A Work	B Work	C Work	Unsatisfactory
Clarity of communication (60%)	• Team shows a clear and unified understanding of the system requirements • Concise communication • Answers to questions are concise and accurate • Well planned and executed • Team has a professional appearance and uses intelligent language	• Minor ambiguities • Minor detractions from briefing	• Team shows basic understanding of the system requirements with a few significant disconnects • Communication of requirements is unclear in few areas • A few questions not well answered • Many colloquialisms, including, "stuff like this", "you guys", and "my bad"	• Requirements not well understood or major inconsistencies in understanding amongst the team • Communication unclear in several areas • Several questions not answered well • Briefing lacks planning • Briefing more than 10 minutes over time
Briefing slides (40%)	• Slides support the delivery of information • Professional • Readable • Well organized • Adequately referenced • Minor if any issues	• Several minor problems	• Information on some slides does not support the point of the briefing • Several format inconsistencies and errors • Minor changes after slides submitted for review • Some slides difficult to read	• Major errors, format problems or readability issues • Several revisions after slides submitted for review • **STUDENT HOURS AND ACTIONS NOT REPORTED**